Patent Application of

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for

DEFLECTION MEASUREMENT DEVICE FOR FLEXIBLE PIPING

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a CONTINUATION of U.S. Application No. 10/021,790, filed on December 19, 2001. The Applicants hereby expressly claim the benefit of the earlier application under 35 U.S.C. §120 and 37 CFR §1.53(b).

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

MICROFICHE APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to the field of piping inspection. More specifically, the invention comprises an adjustable sled which detects and measures vertical and horizontal deflection in the interior diameter of a flexible pipe as it is advanced through the pipe. The device transmits its deflection measurements to the user by simple visual means, eliminating the need for electronic devices.

2. Description of the Related Art.

Piping is commonly used as a means to convey drainage water and other liquids. Buried pipe has traditionally been made of concrete. Concrete's widespread use is attributable to the fact that it is readily available, durable, and quite strong. Concrete piping may be buried deep within the soil without concern for structural failure. Recently, however, more flexible piping has come into widespread use. Flexible piping is often made from thin-gage metals, or polymers such as polyvinyl chloride and polyethylene. Such flexible piping is subject to circumferential deflection when exposed to soil loading.

Proper installation and soil compacting is critical for flexible piping. If the soil surrounding the flexible piping is correctly compacted in layers, a "soil arch" develops over the top of the piping which prevents excessive deflection. If, however, the soil is added around the piping without properly compacting it layer by layer, then the deflection may become excessive. While one would intuitively expect vertical deflection, horizontal deflection also occurs. Excessive deflection can lead to localized or generalized failure of the pipe wall, resulting in a catastrophic leak.

These concerns are heightened when the flexible piping is made of a polymer, since distorting loads tend to produce buckling and cracking in such polymers. Although the cracks may start small, they tend to propagate through the polymer - eventually weakening it to the point of failure. The distorting forces can also produce failures in the joints between two sections of pipe, which must carry the load when one pipe shifts relative to its neighbor.

It is possible to visually monitor the soil compaction process and ensure that it is carried out correctly. However, it is difficult or impossible to determine if the soil compaction has resulted in excessive pipe deflection after the fact. Examination of these deflections is often used as the criterion to determine the acceptability of flexible piping installations. Accordingly, a device for easily measuring such deflections would be useful.

The prior art approach to measuring the deflections has generally been to create a mandrel having an outside diameter equal to the minimum acceptable inside diameter of the piping. A cable is passed through the piping and this cable is used to drag the test mandrel back through. The shortcomings of this approach are as follows:

1. A new mandrel must be made for each pipe size that is to be inspected;

2. A cable must be passed completely through the piping before the mandrel is introduced - often a difficult process in itself;

3. An additional cable must be attached to the trailing end of the mandrel to pull it free if it gets stuck;

4. The mandrel can be lodged by debris in the piping, giving a false impression of excessive deflection; and

5. Once the mandrel reaches a point of excessive deflection it can proceed no further, meaning that the remainder of the piping system cannot be inspected.

Other more sophisticated approaches are found in the prior art. As an example, U.S. Patent No. 6,170,344 to Ignagni (2001) reveals an inspection “pig” equipped with an inertial measurement system (presumably gyroscopes and accelerometers). Another approach employs projected laser beams and video cameras, along with computers running software which can translate the laser projections into distance measurements on the inner wall of the pipeline.

The reader should appreciate that buried piping which is used to convey drainage water - as opposed to oil or natural gas piping - is often filled with water puddles and other contamination. The use of electronic devices is therefore difficult, owing to the rugged nature of the application. An electronics-intensive approach is also inherently expensive. All these limitations are significant.

BRIEF SUMMARY OF THE INVENTION

The present invention is a mechanical inspection sled which can be pushed through a pipeline using a series of connecting rigid rods. Mechanical measuring devices are mounted on the sled. These devices deflect when the pipe’s internal diameter decreases. The deflection is visually observable by the user through a series of reflective indicators. The measuring devices are sufficiently pliable to allow the sled to pass beyond distorted areas and complete a full inspection of the pipeline.

The measurement devices are adjustable to allow the sled to be used in many different pipe sizes. Because the device is purely mechanical, it is quite rugged and able to withstand harsh environments. In addition, very little training is required to use the device.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 is an isometric view, showing the inspection sled.

FIG. 2 is an isometric view, showing details of the rear portion of the sled.

FIG. 3 is an isometric view with a cutaway, showing the inspection sled in a pipe.

FIG. 4 is an isometric view with a cutaway, showing how the inspection sled is advanced through a pipe.

FIG. 5 is an isometric view, showing the deflection of the lateral test arm.

FIG. 5B is an elevation view, showing the operation of the lateral visual indicators.

FIG. 5C is an elevation view, showing the operation of the lateral visual indicators.

FIG. 6 is an isometric view, showing the deflection of the vertical test arm.

FIG. 6B is an isometric view, showing the operation of the vertical visual indicators.

FIG. 6C is an elevation view, showing the operation of the vertical visual indicators.

FIG. 7 is a perspective view, showing the operation of the plumb in keeping the inspection sled level.

FIG. 7B is a perspective view, illustrating the horizontal and vertical diameters of a pipe.

FIG. 8 is an isometric view, showing how the inspection sled can be adjusted to inspect larger pipes.

FIG. 9 is a perspective view, showing two inspection sleds in two pipes having different diameters.

FIG. 10 is an isometric view, showing a gage used for calibration.

FIG. 11 is an isometric view, showing the application of a gage.

FIG. 12 is an isometric view, showing a refined version which represents the preferred embodiment.

FIG. 13 is a detail view of the preferred embodiment.

FIG. 14 is an isometric view, showing the preferred embodiment with its vertical deflection bar translated downward.

FIG. 15 is a detail view of the preferred embodiment.

FIG. 16 is a detail view, illustrating portions of the visual indicator system.

FIG. 17 is a detail view, illustrating portions of the visual indicator system.

FIG. 17B is an isometric view, illustrating details of the visual indicator system.

FIG. 18 is a detail view, illustrating the operation of the visual indicator system.

FIG. 19 is an isometric view, showing another simplified embodiment.

FIG. 20 is a detail view, showing some details of the simplified embodiment.

FIG. 21 is an elevation view, illustrating details of the visual indicator system.

FIG. 22 is an elevation view, illustrating details of the visual indicator system.

FIG. 23 is an elevation view, illustrating details of the visual indicator system.

REFERENCE NUMERALS IN THE DRAWINGS

10	inspection sled	12	runner
14	front tube boss	16	rear tube boss
18	middle tube boss	20	front tube clamp
22	rear tube clamp	24	middle tube clamp
26	forward mast	28	rear mast
30	plumb mast	32	plumb boss

34	plumb clamp	36	plumb bracket
38	plumb	40	pipe
42	forward bracket	44	rear bracket
46	lateral test arm	48	lateral fixed arm
50	vertical test arm	52	plumb pivot
54	plumb weight	56	plumb reflector
58	18"-diameter pipe	60	extension rod
62	rod receiver	64	rod coupler
66	lateral flag	68	lateral indicator
70	vertical flag	72	vertical indicator
74	24" inspection sled	76	24" lateral fixed arm
78	24" lateral test arm	80	24" vertical test arm
82	24"-diameter pipe	84	gage
86	vertical zero	88	horizontal zero
90	calibration steps	92	horizontal diameter
94	vertical diameter	96	bottom region
98	first side region	100	top region
102	second side region	104	vertical deflection bar
106	forward spring bracket	108	rear spring bracket
110	guide rod	112	guide rod hole
114	compression spring	116	stop collar
118	point reflector	120	flex mast

122	contact point	124	tube
126	tube mount	128	orifice
130	reflector	132	reflector card
134	window card	136	first window
138	first reflector	140	second reflector
142	card mount	144	guide slot
146	second window	148	third window
150	fourth window	152	fifth window
154	sixth window	156	seventh window
158	eighth window	160	third reflector
162	fourth reflector	164	fifth reflector
166	sixth reflector	168	seventh reflector
170	eighth reflector	174	ninth reflector
176	tenth reflector	178	eleventh reflector
180	twelfth reflector		

DETAILED DESCRIPTION OF THE INVENTION

The principal objective of the present invention is to measure deformations in the horizontal and vertical diameters of a pipe. The "horizontal diameter" is defined as a measurement of the pipe's internal diameter taken through its centerline in a direction which is parallel to the earth's surface. The "vertical diameter" is defined as a measurement of the pipe's internal diameter taken through its centerline in a direction which is perpendicular to the earth's surface

FIG. 1 illustrates the major components of inspection sled **10**. All the components are mounted on a base element, designated in the view as runner **12**. Runner **12** is a ski-like structure, having upturned ends. It is intended to slide along the inside lower surface of a pipe. Although a wheeled carriage could be employed, runner **12** is simpler and has been found to be satisfactory.

Mounted directly to runner **12** are front tube boss **14**, middle tube boss **18**, rear tube boss **16**, and plumb boss **32**. In the embodiment shown, runner **12** is made from sheet aluminum. The bosses are machined from aluminum blocks. However, those skilled in the art will appreciate that the material selection is simply one of manufacturing expedience. As an example, runner **12** and the attached bosses could be manufactured as an integral piece of glass reinforced polymer - using the reaction injection molding method. As illustrated, the bosses are simply bolted to runner **12**.

Each tube boss has a cylindrical cavity running transversely through it. Pipe **40** is laid into these cavities. Front tube clamp **20**, middle tube clamp **24**, rear tube clamp **22**, and plumb clamp **34** are then placed over the top of pipe **40**. These tube clamps also have transverse cylindrical cavities corresponding to those found in the tube bosses. The tube clamps are bolted to the tube bosses using conventional fasteners, with the result that pipe **40** is mechanically affixed to runner **12**.

Forward mast **26** rises vertically from front tube clamp **20**. Forward bracket **42** is mounted to forward mast **26** by conventional means. Forward bracket **42** is vertically adjustable, so that a user can move it up and down forward mast **26**, locking it in place in a desired position. Rear mast **28** rises vertically from rear tube clamp **22**. Rear bracket **44** is mounted to rear mast **28** in a vertically adjustable manner. The vertical height of forward bracket **42** and rear bracket **44** must be adjusted in unison, as will be explained subsequently.

Lateral fixed arm **48** is attached to forward bracket **42** and rear bracket **44**. It is substantially rigid. It lies in a horizontal plane, which will ideally rest on the horizontal diameter **92** of a pipe being inspected. Opposite lateral fixed arm **48** is lateral test arm **46**. The forward portion of lateral test arm **46** is fixed to forward bracket **42**. The rear portion, however, is free to move. Lateral test arm **46** is made of a resilient and flexible material. Solid aluminum rod is a good choice, as it is able to bend in and out substantially without suffering a plastic deformation. As test sled **10** is advanced through a pipe and encounters a reduction in the horizontal diameter **92** of the pipe, lateral test arm **46** will deflect, with its rearward portion moving inward.

Vertical test harm **50** is the vertical counterpart to lateral test arm **46**. Its forward portion is secured to forward mast **26**, but its rear portion is free to move. If test sled **10** encounters a reduction in a pipe's vertical diameter **94**, vertical test arm **50** will deflect, with its rearward portion moving downward.

It is important that inspection sled **10** remain level during its progress through a pipe. Otherwise, it will not be measuring the true horizontal **92** and vertical **94** diameters of the pipe. Plumb **38** is provided as a leveling aid. Plumb mast **30** rises vertically from plumb clamp **34**. Plumb **38** is pivotally mounted to plumb mast **30**. Plumb bracket **36** restricts the angular travel of plumb **38**.

FIG. 2 - which is a partial view - shows the rear features of inspection sled **10** in more detail. Plumb **38** is attached to plumb mast **30** by plumb pivot **52**. Plumb **38** is free to rotate as indicated by the arrows. Plumb weight **54** ensures that plumb **38** is oriented vertically when inspection sled **10** is level. In that state, plumb reflector **56** is completely obscured by plumb weight **54** (when the device is viewed from the rear).

The reader should appreciate that inspection sled **10** will be introduced into an open end of a pipe and advanced away from the user. The user will customarily shine a light into the pipe to observe the progress of the device. Provided that inspection sled **10** is level, the user will not see any reflection from plumb reflector **56**. However, if inspection sled **10** rotates, plumb **38** will pivot and plumb reflector **56** will be exposed. This informs the user that the device is no longer level and should therefore be adjusted.

FIG. 2 also shows the hollow end of pipe **40**, designated as rod receiver **62**. The user customarily advances the device by sticking another length of pipe into rod receiver **62** and pushing the device forward. Rod receiver **62** is typically equipped with a transverse hole, into which a locking pin from the pushing rod will lock.

FIG. 3 shows inspection sled **10** placed within 18"-diameter pipe **58** (shown with a cutaway). FIG. 4 shows how inspection sled **10** is advanced. Extension rod **60** is placed into rod receiver **62** and the user pushes the device forward, as indicated by the arrow. A number of rigid extension rods **60** are used to advance the device. Each one contains rod coupler **64**, which is a necked-down cylinder which fits within the hollow extension rod **60** before it. Extension rods **60** contain transverse locking pins which automatically lock successive rods together and prevent one from turning relative to its neighbor. Owing to these features, the user can push inspection sled **10** forward and rotate it to keep it level.

FIG. 5 illustrates the operation of lateral test arm **46**. As explained previously, when test sled **10** encounters a reduction in the horizontal diameter **92** of a pipe, lateral test arm **46** deflects inward, as shown by the arrow. Lateral flag **66** is attached to the rearward end of lateral test arm **46**. As

lateral test arm **46** deflects inward, lateral flag **66** moves inward across the rearward face of rear bracket **44**.

FIG. 5B shows a view of the rear of test sled **10** with lateral test arm **46** in its undeflected state. When a force is applied to lateral test arm **46**, lateral flag **66** moves inward in the direction indicated. As it does so, it begins to occlude a series of lateral indicators **68**, which are affixed to the rearward face of rear bracket **44**. This view approximates the user's view of the device, as the user looks down a pipe. FIG. 5C shows lateral test arm **46** in a deflected state. The reader will observe that two of the three lateral indicators **68** have been occluded, thus indicating to the user the state of the deflection. These lateral indicators **68** are typically color-coded strips or dots of highly reflective material. The use of color coding allows the user to discern the degree of deflection of lateral test arm **46** at great distances. It is important to note that test sled **10** conveys all of its information through the use of reflectors. It has no electrical power source whatsoever.

FIG. 6 illustrates the presence of vertical flag **70** on the rear extremity of vertical test arm **50**. As vertical test arm **50** is deflected downward via a reduction in the vertical pipe diameter, vertical flag **70** moves downward across the rearward face of rear bracket **44**. FIG. 6B shows a rear view of vertical test arm **50** in its undeflected state. In this position, vertical flag **70** has not occluded vertical indicators **72**. FIG. 6C shows vertical test arm **50** deflected downward. The reader will observe that vertical flag **70** has occluded two of the three vertical indicators **72**. Again, through the use of color coding in the vertical indicators **72**, the degree of deflection can be observed by the user over considerable distance.

FIG. 7 is a perspective view illustrating test sled **10** traveling through 18"-diameter pipe **58** (pipe **58** is shown with a cutaway). In this illustration, test sled **10** has become canted in a clockwise

direction. The reader will observe that plumb **38** has remained vertical, with the result that plumb reflector **56** is now visible. The user is thereby informed that the device is not level and a correction is made.

FIG. 7B illustrates the measurement objectives of the device. 18"-diameter pipe **58** is roughly divided into top region **100**, right side region **98**, left side region **102**, and bottom region **96**. There is, of course, no clear demarcation between these regions since the pipe is ideally cylindrical. The objective is to measure values for horizontal diameter **92** and vertical diameter **94**. In order to measure these values, the device must be level. Returning to FIG. 7, the reader will observe that the non-level state of the device means that lateral fixed arm **48** and lateral test arm **46** are not lying in the plane of horizontal diameter **92**. Likewise, vertical test arm **50** is not lying in the plane of vertical diameter **94**. A correction is therefore needed and the user can supply this by twisting the push rods as he or she advances the device.

FIG. 7 also illustrates well the device's operation. Lateral fixed arm **48** maintains contact with right side region **98**. Lateral test arm **46** maintains contact with left side region **102**. If a reduction in horizontal diameter **92** is encountered, lateral test arm **46** will deflect. Lateral test arm **46** is sufficiently flexible to allow the device to pass through a substantial constriction and continue onward.

Runner **12** maintains contact with bottom region **96**. Vertical test arm **50** maintains contact with top region **100**. If a reduction in the vertical diameter **94** is encountered, vertical test arm **50** will deflect. It is also sufficiently pliable to allow the device to pass through a constricted area and continue.

Those skilled in the art will appreciate that the width of runner **12** prevents the device from sitting on the lowest point of the pipe's interior. The width of runner **12** must be accounted for in determining the appropriate height of vertical test arm **50**. This is especially true since the device contemplates that many different pipe diameters may have to be inspected.

One inspection sled **10** may be used to inspect a wide range of pipe diameters by incorporating adjustment features. Inspection sled **10** is adapted to inspect an 18"-diameter pipe. FIG. 8 depicts inspection sled **10** next to 24" inspection sled **74**, which is adapted to inspect a 24"-diameter pipe.

24" inspection sled **74** is simply inspection sled **10** adjusted to fit a larger pipe. The reader will observe that forward bracket **42** has been moved up its mast and locked into a higher position. Likewise, rear bracket **44** has been moved upward. Larger test arms are also needed. 24" inspection sled **74** is equipped with 24" lateral fixed arm **76**, 24" lateral test arm **78**, and 24" vertical test arm **80**. All these arms are easily removed and replaced. 24" inspection sled **74** is identical to inspection sled **10** in every respect, other than the vertical and horizontal adjustments and the different arms. In fact, in actual practice, the user will typically use only inspection sled with sets of different arms to accommodate the different pipe diameters.

FIG. 9 shows the two variants side by side. Inspection sled **10** fits tightly within 18"-diameter pipe **58**. 24" inspection sled **74** fits tightly within 24"-diameter pipe **82**. The reader will thus observe how the use of adjustments and the different arm sets allow a single inspection sled to be adapted to fit many different pipe diameters.

It is important to calibrate the inspection sled **10** for the particular diameter of pipe that will be inspected. This goal could be accomplished in many different ways, such as by providing markings on the masts and arms to indicate the correct adjusted positions. FIG. 10 illustrates another approach

using a gage. Gage **84** has horizontal zero **88**, vertical zero **86**, and a series of calibration steps **90**.

FIG. 11 illustrates the use of gage **84**. Inspection sled **10** is placed on flat surface **86**. Gage **84** is then placed against inspection sled **10**, with vertical zero **86** being placed on flat surface **86** and horizontal zero **88** being placed against the side of runner **12**. A particular calibration step **90** (depending on the pipe diameter involved) is use to set the correct position or lateral fixed arm **48**, and likewise for lateral test arm **46**. The calibration steps **90** are marked to indicate which one should be used. A similar gage can be fabricated and employed for vertical test arm **50**.

The device disclosed in FIGs. 1-11 is capable of measuring deflections in a pipe's vertical **94** and horizontal **92** diameters. Practical experience illustrates that a reduction in the pipe's vertical diameter **94** is the more significant measurement, since this indicates settling of the soil around the pipe. A variation only measuring the pipe's vertical diameter **94** can therefore provide the most needed information and also reduce complexity.

In addition, the device disclosed in FIGs. 1-11 has been found to have certain limitations in its visual indicating system. It is common for the user to advance the device up to 100 feet into a pipe. At that distance, it is difficult for the user to discern the degree of occlusion of lateral indicators **68** and vertical indicators **72**. This is true even though different colors are used for successive indicators. At ranges approaching 100 feet, human vision simply blurs the two colors together and makes it difficult to observe the degree of occlusion. Thus, a more sophisticated visual indicating system is desirable.

FIGs. 12-18 illustrate a second embodiment addressing these concerns. Because this version remedies the problems just discussed, it is the preferred embodiment. As seen in FIG. 12, the

structure of inspection sled **10** is the same with only a few exceptions. Because the preferred embodiment is not designed to measure deflections in a pipe's horizontal diameter **92**, it has two lateral fixed arms **48**. Vertical deflection bar **104** is designed to measure reductions in a pipe's vertical diameter **94**, using a refined system. The user will observe that forward spring bracket **106** is attached to forward bracket **42**. Likewise, rear spring bracket **108** is attached to rear bracket **46**.

Both forward spring bracket **106** and rear spring bracket **108** have a guide rod **110** passing through them. Guide rods **110** are free to move up and down relative to the two spring brackets. Vertical deflection bar **104** is attached to the upper end of each guide rod **110**. Springs are employed to bias vertical deflection bar **104** toward its upper position - as shown.

FIG. 13 is a detail view. The reader will observe that the two horizontal portions of forward spring bracket **106** are each pierced by a guide rod hole **112**. Guide rod **110** slides up and down within guide rod holes **112**. Stop collar **116** is adjustably attached to guide rod **110**. Compression spring **114** fits closely around guide rod **110**. Its lower end bears against forward spring bracket **106**. Its upper end bears against the lower surface of stop collar **116**.

Identical components are located proximate rear spring bracket **108**. The result is that the two guide rods **110** are naturally biased upward, resulting in vertical deflection bar **104** being naturally biased upward.

FIG. 14 shows the device as it would appear upon encountering a reduction in a pipe's vertical diameter **94**. Vertical deflection bar **104** has been forced downward as indicated by the arrow, resulting in guide rods **110** moving downward. FIG. 15 shows a detail view of forward spring bracket **106** as vertical deflection bar **104** is forced downward. The reader will observe that guide rod **110** has moved downward as indicated. Stop collar **116** has also moved downward,

resulting in the compression of compression spring **114**. Once the region of reduced vertical diameter **94** within the pipe is passed, compression springs **114** will restore the device to its undeflected state.

The use of this revised system for measuring vertical deflection is quite effective. However, an improved means of visually communicating the degree of deflection to the user is also needed. FIGs. 16-18 and 21-23 illustrate the improved indicating system. In FIG. 16, reflector card **132** has been attached to the rear face of rear bracket **44**. The reader will also observe that card mount **142** has been attached to the rear guide rod **110**. Card mount **142** will also move up and down with guide rod **110**. Accordingly, reflector card **132** is provided with a vertical slot allowing for clearance as card mount **142** moves downward.

In FIG. 17, the reader will note that window card **134** is positioned to be attached to card mount **142** so that it slides up and down with guide rod **110**. Window card **134** has eight windows **136**, which allow the display of reflectors placed on reflector card **132**. Window card **134** is configured to slide up and down over the rear surface of reflector card **132**.

FIG. 17B shows reflector card **132** and window card **134** placed side by side for comparison. Ordinarily, of course, window card **134** would be placed over the front of reflector card **132**. As deflection in the internal diameter for the pipe is encountered, window card **134** slides up and down relative to reflector card **132**. Various reflectors are thereby exposed through the eight windows in window card **134**.

The following is a listing of the reflectors found on reflector card **132** in the preferred embodiment: (1) First reflector **138**, fourth reflector **162**, fifth reflector **164**, and ninth reflector **174** are green; (2) Second reflector **140**, third reflector **160**, seventh reflector **168**, and tenth reflector **176** are yellow; and (3) Sixth reflector **166**, eighth reflector **170**, eleventh reflector **178**, and twelfth

reflector **180** are red. The eight windows on window card **134** are configured to interact with these reflectors in order to convey information to the user.

FIG. 18 shows window card **134** mounted in place. In the view shown, the device has encountered a reduction in the pipe's vertical diameter **94**, resulting in the downward movement of vertical deflection bar **104**. Guide rod **110** has moved downward as indicated. Window card **134**, being connected to guide rod **110**, has moved downward relative to reflector card **132**. The windows on window card **134** are exposing certain reflectors, thereby indicating the degree of deflection to the user.

The arrangement of reflectors on reflector card **132** and windows on window card **134** can be configured to convey a great deal of information. A series of examples is provided in FIGs. 21 through 23.

FIG. 21 shows window card **134** in front of reflector card **132**. The features of reflector card **132** can be seen as hidden lines. In this view, window card **134** has traveled downward with respect to reflector card **132**. A portion of third reflector **160** (yellow) is visible through seventh window **156**.

FIG. 22 shows window card **134** after it has traveled further downward. The reader will observe that a portion of first reflector **138** (green) is visible through first window **136**. Likewise, a portion of fourth reflector **162** (green) is visible through fourth window **150**.

FIG. 23 shows window card **134** after it has traveled still further downward. In addition to the reflectors visible in FIG. 22, the reader will observe that a portion of fifth reflector **164** (green) is visible through fifth window **152**. Thus, through the use of the reflectors, the device can communicate very fine readings on the degree of deflection encountered.

It is obviously important to keep window card **134** aligned with reflector card **132**. Returning now to FIG. 18, guide slot **144** is provided through window card **134**. This slot engages guide bushings mounted on reflector card **132** to prevent skew. For purposes of visual clarity, these guide bushings have not been shown. Those skilled in the art will appreciate that additional windows and reflectors could be provided to convey even more detailed information. The concept for such additional indicators would be identical to that for the ones described.

The preferred embodiment encompasses adjustments allowing it to be used for different pipe diameters. Returning to FIGs. 12 and 13, those skilled in the art will appreciate that the position of the two stop collars **116** on the two guide rods **110** will determine the vertical position of vertical deflection bar **104** in the undeflected state. Thus, adjustment means (such as a set screw and a corresponding series of detents in guide rods **110**) can be provided to allow the user to set the vertical position of vertical deflection bar **104** for a variety of different pipe diameters. Of course, different sets of lateral fixed arms **48** must still be employed.

Some users have expressed a desire for a very simply "pass-fail" version of the device. This embodiment would provide a single indication of a failing condition in a pipe's vertical diameter **94**. FIGs. 19 and 20 illustrate such a device. This is a quick test method that could be followed by more precise methods using other features of the device.

In FIG. 19, inspection sled **10** has two lateral fixed arms **48**. Rising from middle tube clamp **24** is flex mast **120**. Flex mast **120** is typically made from a resilient material and has the general characteristics of an automotive radio antenna. Flex mast **120** is topped by contact point **122**. Point reflector **118** is attached to flex mast **120** just below contact point **122**.

FIG. 20 shows point reflector **118** in more detail. Tube mount **126** attaches tube **124** to flex mast **120**. Tube **124** is hollow (shown with a cutaway). Its forward portion contains reflector **130**. Its rearward portion tapers to orifice **128**. As a user shines a flashlight toward the device in a pipe, light enters through orifice **128**, strikes reflector **130**, and bounces back to the user as a single bright point of light.

The height of contact point **122** is set equal to the minimum acceptable vertical diameter **94** for the pipe being inspected. Likewise, lateral fixed arms corresponding to the minimum acceptable horizontal diameter for pipe the pipe are employed. If contact point **122** encounters a smaller vertical diameter **94**, flex mast **120** will bend backward, angling tube **124** downward. The geometry of the device then prevents the reflection of the user's flashlight beam. From the user's vantage point, the single bright point of light disappears. When this happens, the user knows that a failing condition is present. The user may then wish to reconfigure the device using the window card and reflector card to obtain more information.

Accordingly, the reader will appreciate that the proposed invention provides a simple device for measuring constrictions in the diameter of buried piping. The invention has additional advantages in that:

1. It can be adjusted to inspect different sizes of pipe;
2. It does not require a cable to be passed through the pipe before introducing the inspection device;
3. It is not easily obstructed by puddles or debris within the pipe;
4. It can pass beyond an obstructed diameter to inspect the entire pipe; and
5. It provides a simple visual indication system requiring no internal electrical devices.

Although the preceding description contains significant detail, it should not be construed as limiting the scope of the invention but rather as providing illustrations of the various embodiments of the invention. Thus, the scope of the invention should be fixed by the following claims, rather than by the examples given.